Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Revisions to Rules Authorizing the Operation of Low Power Auxiliary Stations in the 698-806 MHz Band	)	WT Docket No. 08-166
	)	
Public Interest Spectrum Coalition, Petition for Rulemaking Regarding Low Power Auxiliary Stations, Including Wireless Microphones, and the Digital Television Transition	)	WT Docket No. 08-167
	)	
Amendment of Parts 15, 74 and 90 of the Commission's Rules Regarding Low Power Auxiliary Stations, Including Wireless Microphones	)	ET Docket No. 10-24
	)	
Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions	)	GN Docket No. 12-268

COMMENTS OF SHURE INCORPORATED

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Summary

As a global leader in audio electronics, including professional wireless microphones and related audio products, and a frequent participant in the technical and regulatory proceedings in the United States and in other countries affecting wireless microphones, Shure is deeply concerned that elements of the Commission's incentive auction proposal, including TV Band repacking, the creation of exclusive use guard bands, and an elimination of reserve channels, among other measures, would cause significant harm to the wireless microphone community. Today, wireless microphones are critical production tools essential to activities in many sectors—broadcast, entertainment, religious, commercial, educational, and civic—and wireless microphone use continues to expand rapidly to meet increasing demand for more sophisticated productions and advanced audio services. The Commission's proposals, if adopted with disregard to these important uses, will severely reduce the amount of UHF spectrum available for wireless microphone operations. As a part of that significant step, the Commission proposes to eliminate the two wireless microphone reserve channels that serve as critical protections against interference and in fact are the only source of interference-free spectrum for all wireless microphones under the recently established White Space rules. This comes at a time in which the wireless microphone community is still struggling to absorb the significant costs and disruption of the Commission's other recent dramatic changes to the UHF band in the White Spaces proceeding and the abrupt prohibition of wireless microphone operation in the 700 MHz band. Further harm and disruption to the wireless microphone community will have a significant adverse impact on the many sectors in which the professional audio industry operates.

Large and major productions, challenging today, will be severely hindered if access to UHF spectrum is dramatically reduced as proposed. For example, television productions,

professional and college sports, music concerts, theater, corporate events, and religious ceremonies all will be impaired if access to sufficient UHF spectrum is not assured. To avoid this harm, Shure strongly recommends that at a minimum, the two UHF reserve channels are retained and that wireless microphone users are able to operate in the guard bands and gain temporary protection from interference for the time and location of use by registering in the database.

In view of the likely significant reduction in access to UHF spectrum for wireless microphone users, Shure also strongly urges the Commission to expand the class of parties eligible for Part74 licenses to include professional wireless microphone users as set forth in Shure's implementation proposal. Professional users employ wireless microphones similar to broadcast licensees and need similar temporary interference protection in the geolocation database. With respect to the multiple databases, Shure also outlines specific rule changes that will greatly improve their effective operation.

Finally, in response to the Commission's call for information about the development of more efficient wireless microphone technology, including digital technologies, Shure herein provides detailed technical information and analysis of the advancements in wireless microphone spectrum efficiency. Manufacturers have successfully developed innovations in wireless microphone technologies that have significantly increased the number of microphones able to operate within a single TV channel. However, these advancements cannot be attributed to a single innovation or technique and it is not appropriate for the Commission to adopt a mandatory transition to digital technologies or specific spectral efficiency standards. Digital wireless microphones are a promising emerging technology but analog systems still represent the majority of systems in operation. Spectral efficiency improvements require tradeoffs in audio quality,

latency, operating distances, and immunity from interference. Balancing these tradeoffs is an engineering process influenced by the requirements of a particular installation, location, and application, which are well known by the wireless microphone manufacturers and reflected in product designs. As such, the Commission should not legislate a technical solution to address the use of wireless microphone UHF spectrum in demand by other industries. Nonetheless, Shure identifies strategies the Commission can adopt to encourage further efficiency gains—in particular, the need to preserve sufficient interference-free UHF spectrum.

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COMMENTS OF SHURE INCORPORATED

Shure Incorporated ("Shure"), by its undersigned counsel, hereby submits these consolidated Comments in the above-referenced dockets in which the Commission seeks comment on its proposed incentive auction rules[1] and the Wireless Telecommunications Bureau and the Office of Engineering and Technology seek information and analysis to update the record in the wireless microphone proceeding.[2] Consolidated comments are being filed because

[1] *See* Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions, *Notice of Proposed Rulemaking*, FCC 12-118, GN Docket No. 12-268 (rel. Oct. 2, 2012) ("*Incentive Auction NPRM*").

[2] *See* The Wireless Telecommunications Bureau and The Office of Engineering and Technology Seek to Update and Refresh Record in the Wireless Microphones Proceeding, *Public Notice*, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24 (rel. Oct. 5, 2012) ("*Wireless Microphone Notice*").

the issues raised in these proceedings are intertwined and the public interest requires that they be considered together.[3]

I. Introduction

For over 85 years, Shure has been a respected U.S. manufacturer of high-quality audio equipment. Today, headquartered in Niles, Illinois, Shure is a global leader in innovative audio electronics, including professional wireless microphones and related audio products.

Shure has been deeply involved in the developments surrounding TV band White Spaces technology and strategies to share spectrum with wireless microphones.[4] Working closely with the Commission and various stakeholders over the years, Shure helped to develop rules that enable new unlicensed RF devices to operate on unused UHF television channels (470-698 MHz) while ensuring that incumbent television receivers and wireless microphones have meaningful protection from harmful interference.[5] Shure also participated in the Commission's proceedings regarding wireless microphone operations in the 700 MHz band. When the Commission announced a decision to ban wireless microphone operations in the 700 MHz band after a short transition period, Shure was instrumental in assisting users to transition away from that band in compliance with the Commission's decision. In assessing the impact of its new proposals, the Commission should be aware that the wireless microphone community is still struggling to absorb the significant costs and disruption of the White Spaces and 700 MHz band

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[3] *See* Revisions to Rules Authorizing the Operation of Low Power Auxiliary Stations in the 698-806 MHz Band, WT Docket No. 08-166, Public Interest Spectrum Coalition, Petition for Rulemaking Regarding Low Power Auxiliary Stations, Including Wireless Microphones, and the Digital Television Transition, WT Docket No. 08-167, Amendment of Parts 15, 74 and 90 of the Commission's Rules Regarding Low Power Auxiliary Stations, Including Wireless Microphones, ET Docket No. 10-24, *Order*, DA 12-1926 (2012).

[4] Shure is also actively engaged in related spectrum proceedings in several jurisdictions outside the United States.

[5] Shure was involved in all phases of FCC laboratory and field testing to evaluate the viability of different cognitive radio technologies proposed for White Space operation, contributed extensive engineering resources and hardware to the FCC test effort, and coordinated FCC field tests at FedEx Field (home of the NFL Redskins) and Broadway to evaluate cognitive radio technologies in real-world environments.

decisions and any actions that further impair their wireless microphone operations will cause substantial hardship.

The Commission's proposals aim to overhaul the permissible uses of UHF spectrum that for decades has been allocated on a primary basis to TV, and on a secondary basis, to other services including wireless microphone services.[6] Today, wireless microphone operations are embedded in many sectors and wireless microphone use is rapidly expanding to meet increasing demand for more sophisticated productions and advanced audio services. The Commission's proposed actions are intended to "free up" UHF-TV channels by establishing a reverse auction in which broadcasters would voluntarily relinquish their spectrum, repacking or reorganizing the UHF band to accommodate the remaining TV stations, identifying new UHF spectrum to be auctioned off to wireless providers, and guard bands for the use of unlicensed devices, and a forward auction in which the newly identified wireless spectrum would be sold to the highest qualifying bidder.

Shure appreciates the Commission's effort to identify new spectrum to meet demand for expanded broadband services. However, Shure strongly believes that the Commission must balance the public interest in developing spectrum for additional wireless services with the public interest need to support existing and expanding uses of UHF spectrum by wireless microphone users and other incumbents. Shure is deeply concerned that elements of the Commission's incentive auction proposal would cause significant harm to the wireless microphone community.

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[6] "Wireless microphones" as used herein includes a variety of audio devices authorized under Part 74 of the Commission's Rules as secondary users of locally unoccupied television channels. In addition to wireless microphones, this equipment includes in-ear monitors, wireless intercoms, wireless assist video devices ("WAVDs") and wireless cueing ("IFB") systems.

Shure herein addresses the need to preserve access to UHF spectrum for wireless microphones where possible including the reserve channels. Shure also recommends specific licensing and other measures that will go far to protect wireless microphone operations while allowing new unlicensed and licensed services to use UHF spectrum.

Finally, Shure submits detailed technical information and analysis of advancements in wireless microphone spectrum efficiency in order to help the Commission gain a better understanding of how technology advancements in the context of the unique technical demands of wireless audio can be expected to make possible more spectrally efficient wireless microphones. Shure specifically identifies strategies the Commission can adopt to encourage further efficiency gains.

II. The Public Interest Requires the Commission To Protect Wireless Microphone Operations

A. Wireless audio systems are critical production tools used across a variety of important industries

The Commission is well aware of the vast number of industries that depend on the operation of wireless microphones.[7] In response to proposals forwarded in the White Spaces proceeding (ET Docket No. 04-186) calling for substantial changes to the amount of radio frequency spectrum available for wireless microphones and related professional audio equipment, many organizations and individuals who rely on wireless microphones in a wide variety of sectors voiced strong concern and urged the Commission and Congress to protect

[7] The Commission "continue[s] to recognize that wireless microphones are currently used in many different venues where people gather for events large and small and many consumers and businesses have come to rely on these devices." Unlicensed Operation in the TV Broadcast Bands, ET Docket No. 04-186, Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, ET Docket No. 02-380, *Second Memorandum Opinion and Order*, 25 FCC Rcd 18661, ¶ 29 (2010) ("*White Spaces Second Order*").

wireless microphone operations.[8] The extensive record developed through the course of the multi-year White Spaces proceeding clearly demonstrates that organizations large and small, from the church with a few dozen members[9] to mega-churches with thousands of members and Internet webcasts,[10] from the local high school or community theater[11] to Broadway productions,[12] rely upon wireless microphones to deliver clear, real-time audio to their audiences.[13] Other organizations, such as broadcasters, film producers, sports leagues, music tours and venues, academic institutions, corporations, government bodies, hotels, convention and conference centers, and theme parks have all made clear how important interference-free wireless microphone operations are to their businesses.[14] The economic value of these

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[8] *See, e.g.*, Interference Protection for Existing Television Band Devices Act, H.R. 1320, 110th Cong. (2007); Letter from Representative Charles B. Rangel to Chairman Martin, ET Docket No. 04-186 (filed Oct. 28, 2008) (urging the Commission to pay attention to "incumbent users of the white space spectrum . . . [and] to promote our economy and protect the livelihood of tens of thousands of broadcast and theatrical union workers in television stations and theatres on Broadway and across this country").

[9] *See, e.g.*, Letter from James Cotter, Pastor, Columbus United Methodist Church, to Chairman Martin, ET Docket Nos. 04-186, 02-380 (filed Oct. 29, 2007) (stating that the church relies on wireless microphone operations to "energize our worship and communicate more effectively to people with hearing problems").

[10] *See, e.g.*, Letter from Joel Osteen, Senior Pastor of Lakewood Church to Chairman Martin, ET Docket No. 04-186 (filed Oct. 7, 2008) (noting that "40,000 people attend Lakewood Church" in addition to live streaming audience, that the church travels to multiple cities around the country, and that "[i]n all of these activities, wireless microphones are essential to their success").

[11] *See, e.g.*, Letter from R. Denny Evaul, Advisor to Masque & Mime Society of Roy C. Ketchem High School, ET Docket No. 04-186 (filed Oct. 27, 2008) (noting that the 27 wireless microphones used by the high school drama group were a "significant investment" and that "the impact, if they were to become useless, would be disastrous").

[12] *See* Ex Parte Comments of the Broadway League, ET Docket No. 04-186, at 3 (filed June 18, 2008) (noting that wireless microphones systems are essential to productions and that "[t]heatre patrons are highly unlikely to forgive lackluster sound quality, frequent interference or highly scaled-back productions") ("*Broadway League Comments*").

[13] The Commission has acknowledged that the record in the White Spaces proceeding "includes a number of comments that describe the need for and the significance of wireless microphones in providing quality audio technology for performances and programs in theaters, classrooms, lecture halls, houses of worship, stadiums, and other venues." Revisions to Rules Authorizing the Operation of Low Power Auxiliary Stations in the 698-806 MHz Band, WT Docket No. 08-166, Public Interest Spectrum Coalition, Petition for Rulemaking Regarding Low Power Auxiliary Stations, Including Wireless Microphones, and the Digital Television Transition, WT Docket No. 08-167, Amendment of Parts 15, 74 and 90 of the Commission's Rules Regarding Low Power Auxiliary Stations, Including Wireless Microphones, ET Docket No. 10-24, *Report and Order and Further Notice of Proposed Rulemaking*, 25 FCC Rcd 643, ¶ 87 (2010) ("*Wireless Microphone Order*").

[14] *See, e.g.*, Comments of MGM MIRAGE, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24, at 1-4 (filed Feb. 23, 2010); Comments of Second Baptist Church, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24, at 1-2 (filed Feb. 26, 2010); Comments of Central Synagogue, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24, at 1-2 (filed Feb. 12, 2010); Comments of Phil Ramone, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-

enterprises is tied to the interference-free operation of high-quality wireless microphones and reaches billions of dollars annually.[15] For all entities affected, the loss of spectrum that enables reliable wireless microphone operation, or imposition of new regulations that require users to make an unbudgeted substantial capital outlay on new equipment will significantly harm these sectors and undermine the U.S. economy.

The extensive use of wireless microphones in a plethora of U.S. businesses and organizations cannot be dismissed and remains just as important today as when the FCC opened the White Spaces proceeding in 2004. Wireless devices allow users and content producers the unrestricted freedom of movement that is necessary to create the full impact of a performance or communication. There are simply no suitable replacements for the operation of professional

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24, at 1-2 (filed Feb. 24, 2010); Comments of US Airways Center, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24, at 1 (filed Feb. 17, 2010); Comments of The Senate of The State of Texas, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24, at 1-3 (filed Feb. 17, 2010); Comments of Macalester College, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24, at 1 (filed Feb. 16, 2010); Comments of Andre Pessis, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24, at 1 (filed Feb. 19, 2010); Comments of Yerba Buena Center for the Arts, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24, at 1 (filed Feb. 22, 2010); Comments of Kenneth "Babyface" Edmonds, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24, at 1 (filed Feb. 19, 2010); Letter from Sports Technology Alliance to Chairman Kevin J. Martin, *Ex Parte* in ET Docket Nos. 04-186, 02-380 (filed Aug. 21, 2008); Letter from Charlotte St. Martin, Executive Director, The Broadway League, to Chairman Kevin J. Martin, ET Docket No. 04-186 (filed June 10, 2008).

[15] *See Broadway League Comments* at 2 ("The most current statistics on Broadway's economic significance demonstrate that this industry annually contributes more than $5.1 billion to the City of New York and generates the equivalent of 44,000 full time jobs."). MGM Mirage, which employees over 66,000 people and generated over $8.8 billion in revenues in 2012, relies heavily upon the use of wireless microphones in all of its properties. *See* Letter from Alan M. Feldman, Senior Vice President, Public Affairs, MGM Mirage to Chairman Genachowski, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24 (filed Feb. 23, 2010) ("*MGM Mirage Letter*"); MGM Resorts International (NYSE:MGM) Public Company Profile, Capital IQ, Dun & Bradstreet, Inc. (2013); *see also* The Kennedy Center Inc. Private Company Profile, Capital IQ, Dun & Bradstreet, Inc. (2013) (estimated $24.5 million in annual revenue in 2012); Cirque du Soleil, Inc., Private Company Profile, Capital IQ, Dun & Bradstreet, Inc. (2013) (estimated $331.9 million in annual revenue in 2012); and Live Nation Entertainment, Inc. (NYSE:LYV) Public Company Profile, Capital IQ, Dun & Bradstreet, Inc. (2013) ($5.568 billion in annual revenue in 2012). In addition to the direct users of these devices, a whole network of businesses including large and small media companies, rental houses, production companies, and consulting audio engineers, have developed businesses and livelihoods that rely, in part, upon the ability to operate professional grade wireless microphones. *See, e.g.*, Letter from Brian J. McGovern, Owner, High Wattage Entertainment LLC, ET Docket No. 04-186 (filed Nov. 13, 2007) ("Over the past 3 years, we've built a small wireless microphone system to better serve our clients. We're a small company and every purchase we make is considered very carefully . . . . Having comparatively low revenues, we don't have the resources to replace the system to the functionality it is at today."); Letter from Kevin McCarthy, Monitor Engineer for Linkin Park, Judas Priest, *et al.*, ET Docket No. 04-186 (filed Oct. 27, 2008) (noting that without wireless technology, "live performances would not be as exciting and popular as they are").

wireless audio systems and, in fact, the demand for wireless audio technology is soaring as audiences in all contexts demand more and more complex and sophisticated productions.[16] Virtually all modern productions—recorded and live, public and private, commercial and religious—incorporate wireless microphone technology and would simply not be feasible if policies severely hampered the desired deployment of wireless microphones.[17] With more than 35 years of successful deployment, wireless audio has become integral to the country's content creation engine, so much so that use of the technology is a given. Today, wireless technology is essential to most major sporting events and in many cases has been incorporated into the game itself, such as the NFL use for referees and for on-field, real time coach to quarterback communications.[18] Professional wireless equipment is also commonly deployed in a wide variety of other forms not visible to the audience but equally important for a safe and successful event, including in-ear monitors for performers, intercoms for stage and security crews, cueing systems for on-air talent, and control systems for sets and scenery. Often inconspicuous in its visibility, professional wireless equipment supports a myriad of events in the U.S. every day—from local to international in profile. The number of frequencies in use at these events can vary

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[16] Examples of sophisticated productions include Cirque du Soleil, broadcast award shows, major sporting events, and large religious assemblies.

[17] Imagine the Lion King prowling across a Broadway stage singing the "Circle of Life" while a long microphone cord trails behind the singer. *See* Comments of the Microphone Interest Coalition, ET Docket Nos. 04-186, 02-380 (filed Feb. 1, 2007) ("Wireless microphones also give artists and performers freedom of movement, enabling innovative and even acrobatic productions such as Cirque du Soleil that could not possibly be put on with wired products."); *see also Wireless Microphone Order* at ¶ 87 n.259 ("In addition, a number of parties have pointed out that wireless microphones provide significant safety benefits for performers and event staff."); *MGM Mirage Letter* at 2 ("Stage crews rely on wireless gear to implement elaborate set and performer changes. Wireless communications play a critical safety role, and are considered show critical systems.").

[18] *See Ex Parte* Comments of Major League Baseball (MLB), the National Association for Stock Car Auto Racing (NASCAR), the National Basketball Association (NBA), the National Collegiate Athletic Association (NCAA), the National Football League (NFL), the National Hockey League (NHL), the PGA Tour, and ESPN as members of the Sports Technology Alliance, ET Docket No. 04-186 (filed May 1, 2008) ("[W]ireless communications systems have become an important infrastructure element in the conduct of the games themselves. Wireless microphones, including intercoms, are used extensively . . . by coaches to communicate with each other and athletes, and by referees to announce penalties and calls.").

from a few to several hundred, but none of the productions would be possible without clean, interference-free spectrum in which to operate.

Furthermore, wireless microphones must not be viewed in a vacuum as a technology divorced from or inconsistent with the Commission's policy goals to expand the availability and use of mobile broadband.[19] Wireless microphones make possible the high-quality, advanced audio services that are a fundamental part of the content that consumers want to access through broadband services. They are on the front end of the "content" chain that feeds into a variety of traditional (*e.g.*, broadcasting) and new (*e.g.*, Internet) multimedia distribution systems. The European Union has recognized the connection and importance of wireless microphones to the success of broadband services.[20] Continued protection of wireless microphone operations in the UHF spectrum is a key part of, rather than an obstacle to, meeting the public demand for mobile broadband services to access multimedia applications.

B. Wireless audio differs from wireless communications

Live audio has significantly different audience expectations and technical requirements than wireless voice or data communications. Listeners expect the quality of audio transmitted over a wireless microphone to be substantially better than the quality of sound over a mobile phone. A theater production, singer at a concert, speech at a convention, or the voice of a referee announcing a call during a game must be heard clearly and instantaneously. There is no "second take" of a live event. In contrast, in a wireless voice or data context, users are much more

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19 *See Incentive Auction NPRM* at ¶ 1.

20 "Wireless microphones and similar applications such as cordless cameras represent a high social, cultural and economic value in Europe. Such technologies, commonly summarised as PMSE ('programme-making and special events'), are essential contributors to the production of the rich media content that will be critical to the success of the high speed broadband services to be delivered over fibre networks. In addition, PMSE applications are also supporting musical and theatrical performances, sport, social and cultural events in the professional and non-professional field." European Commission, *Spectrum for Wireless Events*, http://ec.europa.eu/information_society/policy/ecomm/radio_spectrum/sectorial/shared_use/pmse/index_en.htm (last visited Jan. 15, 2013).

tolerant of delays, pops, or clicks in transmission and even the occasional dropped call or connection, while wireless microphones are held to an exacting standard and are expected to capture and reproduce the full dynamic range of sound audible to the human ear with virtually no latency, artifacts, or distortion.[21]

III. The Wireless Microphone Community is Still Struggling to Absorb the Substantial Disruption and Cost Stemming from the FCC's White Space Rules and 700 MHz Displacement

A. Many wireless microphone users were recently compelled to replace their equipment after only a brief transition period

The extensive further transformation of UHF spectrum allocations proposed in the Wireless Microphone and Incentive Auction proceedings comes amidst recent dramatic regulatory changes imposed on the wireless microphone industry that have mandated significant modifications to wireless microphone users' operations and equipment.

These changes stem firstly from the Commission's recently completed White Spaces proceeding in which, after more than six years of difficult debate and testing, the Commission mandated that yet-to-be-developed unlicensed devices would be permitted to operate in the same UHF spectrum previously identified for wireless microphone operations and other incumbent users.[22] The White Space rules fundamentally altered the UHF landscape for pro audio, which for decades had operated in the vacant TV spectrum without interference to over-the-air broadcasting and with suitable quantities of spectrum to accommodate the increasingly complex productions fueled by American audiences. Understanding this dilemma, the Commission adopted a series of protections designed to ensure that wireless microphones and other existing

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[21] For example, analog wireless microphones introduce an insignificant amount of latency into the transmission of the user's voice compared to 20-100 milliseconds for carrier grade wireless telecommunications equipment (*i.e.*, mobile phones).

[22] *See* Unlicensed Operation in the TV Broadcast Bands, ET Docket No. 04-186, Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, ET Docket No. 02-380, *Second Report and Order and Memorandum Opinion and Order*, 23 FCC Rcd 16807 (2008) ("*White Spaces Order*").

UHF spectrum users would not suffer debilitating interference from the new devices authorized to share the spectrum. Among a host of specific technical rules, the regulations identified two wireless microphone UHF reserve channels and implemented a new geolocation database in which licensed and certain unlicensed wireless microphones would be able to register for interference protection.[23]

Secondly, while the Commission was considering White Space regulations, it decreed an additional change on the wireless microphone community when it stated that, in a short six-month time frame, wireless microphone operations would be banned in 700 MHz (698-806) frequencies—over one third of the formerly available operating bandwidth.[24] As a result of the order, after more than thirty years of FCC regulation authorizing wireless microphone use and manufacturing in 700 MHz frequencies, wireless microphone users were instructed to cease using their 700 MHz wireless microphone systems, many of which had not run the course of their useful product life.[25] Although the long-term fate of the 700 MHz band was foreshadowed by the DTV transition and subsequent auctions, rules and timing for wireless microphone operations were not and, by regulatory fiat, wireless microphone users were faced with substantial unbudgeted capital expenses in a very brief time period, requiring an industry-wide effort to retire fully functional equipment and re-deploy in the new "safe harbors" that were identified in the White Space rules.[26]

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[23] *White Spaces Second Order* at ¶ 32 ("Entities desiring to operate wireless microphones on an unlicensed basis without potential interference from TVBDs may use the two channels in each market area where TVBDs are not allowed to operate . . . . Entities operating or otherwise responsible for the audio systems at major events where large numbers of wireless microphones will be used and cannot be accommodated in the available channels at that location may request registration of the site in the TV bands databases.").

[24] *Wireless Microphone Order* at ¶ 86.

[25] The standard life cycle of a professional-grade wireless microphone and audio system is 5-10 years with many systems able to operate substantially longer.

[26] *See* Comments of Village Church of Gurnee, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24 (filed March 1, 2010) (noting that the church spent $50,000 on new equipment to move out of the 700 MHz spectrum); Comments of Association of Performing Arts Presenters, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24, at

Taken together, the 700 MHz transition and the White Space rules have resulted in significant capital outlay and retraining for the country's wireless audio users, distributors, and manufacturers. Thanks to a concerted effort by the industry, the information is being disseminated and the proper equipment is increasingly available. This good faith effort on behalf of the pro audio industry, however, comes with an expectation that its cooperation will be met with regulations that offer a reasonable degree of certainty for the large population of users and the industries that rely on the operation of this equipment. The *Incentive Auction NPRM* and open issues surrounding licensing of wireless microphone operations serve to reduce this certainty.

B. The Commission advised wireless microphone users that they would be able to operate in TV spectrum

After removing wireless microphones from the 700 MHz band and establishing the White Space guidelines, broadcasters, venues, equipment rental companies, houses of worship, sports and theater productions, conventions, music tours, and many other wireless microphone users struggled to find available channels in the lower part of the UHF TV band. In order to keep operating, they turned to guidance from the FCC to purchase and use new wireless microphone equipment that would operate on frequencies in the UHF band below 698 MHz and be protected from interference from White Space devices under the new rules. As part of its guidance to consumers and its consumer advisory instructing users to stop using wireless microphones in the 700 MHz band, the FCC advised users that they "may continue to use wireless microphones (and

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3 (filed Mar. 1, 2010) (noting that members have invested $3,000 to $850,000 in wireless microphone equipment); Comments of Second Baptist Church, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24 (filed Feb. 26, 2010) ("Second Baptist Church recently made the investment to upgrade all of our 700 MHz equipment to become compliant with new FCC regulations. This was a very costly endeavor that involved 67 units at an average cost of $1,500 each, for a total cost of approximately $105,000."); Letter from John Higbee, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24 (filed Feb. 21, 2010) (noting that the Tropicana Casino & Resort spent over $70,000 on new equipment to vacate the 700 MHz band).

similar devices) that operate on other broadcast frequencies."[27] While various user groups informed the FCC they would obey the Commission's instruction to vacate the 700 MHz band, they also expressed deep concern that the unexpected capital investment necessary for new equipment would need to be sufficient for years to come and they must not be required to invest and relocate again.[28] For example, the Second Baptist Church, after investing over $100,000 in new equipment to move out of the 700 MHz spectrum, was "concerned that our new equipment will be rendered unreliable or obsolete by interference from new TV Band Devices or from further reductions in available spectrum for wireless audio equipment operation."[29] The Commission's official advice will be shown to be misleading and detrimental to the wireless microphone community if it adopts the proposed restructured use of the UHF spectrum outlined in these proceedings, in particular the possible elimination of the two reserve wireless microphone channels without expansion of license eligibility to include those operators who will require "real time" interference protection in any White Space channels that remain.

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[27] FCC Consumer Advisory, *Operation of Wireless Microphones (and Similar Devices) in 700 MHz Band were Prohibited after June 12, 2010*, http://transition.fcc.gov/cgb/consumerfacts/wirelessmic_advisory.pdf. *See also Wireless Microphone Order* at ¶ 70 ("Those licensees, however, whose current authorization limits them in whole or in significant part to operations in the 700 MHz Band can be accommodated with the use of spectrum from the core TV bands that are available for low power auxiliary station operations under Section 74.802 of the rules. Such licensees may wish to consult with a local Society of Broadcast Engineers (SBE) coordinator to identify suitable spectrum from other spectrum bands that are available for low power auxiliary station operations under Section 74.802 of the rules.").

[28] *See, e.g.*, Comments of Impulsive Audio Consultants, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24, at 1 (filed Mar. 1, 2010) ("The change from the 700 MHz band for these devices has already caused a significant hardship on many users during these hard economic times."); Ex Parte Letter from McLean Bible Church, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24, at 1 (filed Feb. 19, 2010) ("We are a house of worship who just spent several $100K on wireless mic replacements to evacuate the 700Mhz band. We are operating in other TV bands and would like to be able to license our systems so that we have a guarantee of reliability.").

[29] *See* Comments of Second Baptist Church, WT Docket Nos. 08-166, 08-167, ET Docket No. 10-24 (filed Feb. 26, 2010). The church also stated that if the new equipment is hampered, "it is within reason that we will need to repeat this prohibitively expensive process in the future, or, in the worst case scenario, be left with no commercially available products to continue our operations at their current level of quality." *Id*. at 2.

IV. The Public Interest Will Suffer If Wireless Microphones' Access to UHF Spectrum is Dramatically Reduced

A. The Commission's spectrum band proposal will harm wireless microphone users

After enduring expulsion from the 700 MHz spectrum and the threat of interference from new wireless devices, wireless microphone users are again faced with another significant UHF spectrum reduction through auction and repacking. In addition, a mere two years after the establishment of the two UHF reserved channels, the FCC now seeks comment on eliminating those channels. Negative outcomes for professional audio in either of these scenarios will undoubtedly jeopardize a significant portion of the nation's wireless microphone users and operations. Combined, they would leave operators with little, if any, UHF spectrum to operate free from interference less than 5 years after the DTV transition. This policy direction runs counter to the pro audio industry's observation of an increasing U.S. demand for wireless microphones and related equipment and their deployment in an ever-widening amalgam of industries and productions. To suffocate the nation's content creators in the interest of delivering that content faster via wireless broadband connections is, in Shure's view, fundamentally out of balance.

B. Large and major productions will be impaired

The Commission's vision of a reconfigured UHF spectrum plan will not serve the public interest without definitive actions to determine how the audio needs of large events can be supported. Both today's licensed and unlicensed wireless microphone users will potentially have far less UHF spectrum to support the myriad productions that rely on high numbers of wireless microphones including, for example, major broadcast events *(e.g.*, the recent national political conventions and campaign coverage, the upcoming Grammy and Oscar awards shows, *etc.*), major music productions (*e.g.*, the 2012 Bruce Springsteen tour), theater (*e.g.*, matinee and

nightly shows on Broadway and Cirque du Soleil in Las Vegas and elsewhere), sports productions (*e.g.*, the 2012 NFL Super Bowl and play-off games, college basketball), large houses of worship (*e.g.*, Willow Creek, Cherry Hills, and Second Baptist), business conventions and corporate product launches (*e.g.*, 2013 Consumer Electronics Show and Microsoft Xbox 2012 Media briefing). The professional audio component of these events is highly complex. In some cases, hundreds of wireless microphone systems are necessary to support the production. As the Commission noted, "[t]heatrical and sports productions and other major events often use more than 100 wireless microphones, which in certain locations could use most if not all of the UHF channels available to them in the television bands."[30] Additionally, the spectrum challenges are exacerbated when outside media cover events of this nature, as they will seek to use the same available frequencies as the event producers. The *Incentive Auction NPRM* demonstrates a clear threat to these nationally significant political, economic, and cultural operations without a clear path forward as to how they might be accommodated in the future.

C. There are no suitable alternatives to UHF spectrum

Through this next transition, it is imperative that the Commission preserve sufficient clean UHF spectrum for the operation of wireless microphones. Today, UHF spectrum is the primary band for the development and use of wireless microphones both in the U.S. and internationally. Nearly all industrialized nations with significant media development provide for operation of wireless microphones within the UHF band. Given the historical and current primary use of UHF for wireless microphones, the majority of the research and development of professional wireless audio technology has been concentrated in the band. This spectrum provides the optimum balance of signal characteristics and has important technical advantages for wireless microphone operations. No other spectrum with comparable characteristics is

[30] *Incentive Auction NPRM* at ¶ 223.

available. Given the long successful history of spectrum sharing with broadcast television, the technical advantages of the UHF spectrum for wireless microphones, and the fact that other major markets support wireless microphone operations in the UHF bands, Shure believes that UHF is the best spectrum choice for wireless microphones now and in the future.

V. The FCC Must Protect Access to the Remaining Available UHF Spectrum

The proposed reduction in the amount of UHF spectrum available for wireless microphones must be balanced with expanded eligibility for Part 74 FCC licensing and easier geolocation database registration. Professional wireless microphone users, in particular, must be able to ensure that their productions can continue without risk from interference by reserving spectrum for their wireless microphone use at specific locations and for limited time periods required for the production of their event.[31] Due to the dramatic reduction of available clear UHF spectrum for professional audio starting from the DTV transition through the proposed incentive auctions, in addition to preserving the two reserve channels, the expansion of licensing and simplification of the database registration process are essential to ensuring that professional wireless microphone users will preserve the continuity of their operations without interference.

A. The two wireless microphone reserve channels must be retained

The two reserve channels must be preserved for the exclusive use of wireless microphones and related professional audio equipment. As the Commission has already determined, the two reserve channels are the only means by which users can be certain to have interference-free spectrum available for unlicensed wireless microphone use. Interestingly, the reserve channels are now viewed by many *licensed* operators as the foundation of any solid frequency plan, due to the fact that they will be guaranteed to be free from interference. Database registrations were intended to allow operators to "scale up" for larger productions by

[31] See Part VII on proposed licensing requirements.

reserving White Space channels needed for the event (with unlicensed operators having to request approval 30 days in advance). Incentive auctions and repacking will inevitably lead to fewer White Space channels nationwide, thereby making the two reserve channels critical for *all* wireless microphone operators, regardless of license status.

With its adoption of rules governing the operation of White Space devices in the TV spectrum, the Commission concluded that wireless microphones serve a vital function and must have a protected space to operate. The Commission understood "the important function that wireless microphones serve and . . . that it is in the public interest to preserve spectrum in the TV bands that is available for their use."[32] The demand for clean, interference-free spectrum continues to skyrocket, and many wireless microphone users will rely solely on the existence of the reserve channels to ensure that they can operate their audio systems. Some users, knowing they may not have access to licenses or may not be able to register in the database, instead invested heavily in equipment that would safely operate in those bands upon their eviction from the 700 MHz spectrum.[33]

Given the overwhelming demand for wireless audio and the potential reduction of White Space channels in cities across the country, not only should the Commission preserve the two reserve channels for wireless microphone operation, but it should also take additional actions on expanding license eligibility to ensure that professional wireless microphone users can continue

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[32] *White Spaces Order* at ¶ 151. Based on that public interest need, the Commission in 2008 "preserve[d] unoccupied TV channel space below channel 21 for wireless microphones" as well as on two reserved channels in the thirteen identified markets where PLMRS and CMRS systems were operational. *Id.* Later, in response to further input and petitions from wireless microphone users and others, the Commission expanded the two reserved channels nationwide in order to "provide frequencies where a limited but substantial number of wireless microphones can be operated on any basis without the potential for interference from TV bands devices." *White Spaces Second Order* at ¶ 29. *See also id.* at ¶ 132 ("Reserving two channels nationwide will ensure that at least two channels remain available for wireless microphones in all markets.").

[33] *See supra* note 30.

to operate to the best of their ability after the incentive auction and repacking process is completed.

B. Wireless microphones should be given priority access in the guard bands

As currently proposed, the incentive auction will result in an overall reduction in the amount of available UHF spectrum for wireless microphones. As part of that process, the Commission has recommended the creation of guard bands that will be located between the 600 MHz uplink spectrum and upper TV channels and a second guard band located between 600 MHz downlink spectrum and lower TV channels.[34] In proposing to allow unlicensed use in the guard bands, the Commission believes it will "increase the spectrum available for unlicensed use in the urbanized areas of major markets where there may be little or no White Space spectrum available now, spurring deployment, use and a national market for unlicensed devices and applications."[35] In addition, the Commission has requested comment on whether wireless microphones should be permitted to operate in the guard bands and, if so, on what basis.[36]

While necessary to prevent harmful interference to TV from LTE operations, the guard bands should also support the operation of wireless microphones registered in the database. As already demonstrated, wireless microphone users are severely constrained for reliable spectrum in "urbanized areas of major markets," and priority use of the guard bands by wireless microphones will be critical to meet this demand.

In order to maximize use of the guard band spectrum and offset any reductions in TV White Space as a result of repacking, Shure recommends that the Commission apply the White Space rules to the guard bands and allow wireless microphone users priority access to the guard bands at specific locations and at specific times through user registration in the database, or

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34 *Incentive Auction NPRM* at ¶ 126 and Figure 4.
35 *Id.* at ¶ 234.
36 *Id.* at ¶¶ 226, 234.

access on a co-equal basis if no registration is made. This approach is well within the Commission's discretion, since Congress provided for a flexible design and use of these guard bands.[37]

VI. Wireless Microphone Users Need Expanded Interference Protection Through Licensing

A. Existing licensing requirements are antiquated and must be modernized

The current eligibility requirements for Part 74 wireless microphone licenses were developed in the 1970s and, with one minor exception, have not been updated in more than 30 years.[38] In the intervening decades, advancements in technology, the increased production of electronic media, and the quality trajectory of professional audio equipment has fueled the creativity of the nation's content and event producers and, correspondingly, greatly expanded the use of wireless microphones. As a result, the existing list of entities eligible for licensing covers only a small fraction of the population now using wireless audio on a daily basis to create socially, culturally, and economically valuable productions.[39] The Commission has already recognized that, although many live performances and events are not broadcast or recorded, the producers of such events have the same wireless microphone requirements as the producers of live events that are broadcast or recorded.[40] While not all wireless microphone users need to be eligible for licensing (or database protection), users who have audio quality and reliability

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[37] *See* Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96, § 6407(c), 126 Stat. 156 (2012). Congress provided that the "Commission *may* permit the use of such guard bands for unlicensed use" (emphasis added). The Congressional statute does not prohibit licensed use or prioritization of use of the guard bands.

[38] *See* Amendment of Part 2, and Subpart D, Part 74 of the Commission's Rules and Regulations, with Respect to the Use of Wireless Microphones, *Report, Memorandum Opinion and Order*, 63 F.C.C.2d 535 (1977).

[39] Currently, the only entities eligible for a Part 74 license are (1) licensees of AM, FM, TV, or international broadcast stations or low-power TV stations; (2) broadcast network entities; (3) certain cable television system operators; (4) motion picture and television program producers; and (5) certain entities with specified interests in Broadband Radio Service and Educational Broadcast Service licenses. *See* Amendment of Parts 15, 74 and 90 of the Commission's Rules Regarding Low Power Auxiliary Stations, Including Wireless Microphones, *Report and Order and Further Notice of Proposed Rulemaking*, FCC 10-16, ET Docket No. 10-24, ¶ 124 (2010).

[40] *Id.* at ¶ 129.

requirements that are similar to broadcast productions, who regularly need to use more spectrum than what is available in the wireless microphone reserve TV channels, or whose events require wireless microphones as an integral part of those productions should be eligible to apply for a license.

The expansion of license eligibility is imperative in the context of the likely further reduction of wireless microphone access to UHF spectrum. Currently, the reserve channels are the only option immediately available for known, clean spectrum for important unlicensed users (*e.g.*, government buildings, civic auditoriums, houses of worship, corporate meetings and events, convention centers, music tours and venues, and theater performances). Elimination of any portion of the reserved channel allocations increases the burden on unlicensed operators to plan all events 30 days in advance, which is simply not practical for professionals operating in the fluid environment of modern audio-visual production across a variety of industries. Acquiring licenses to operate wireless audio equipment—and the near-real time access to the geolocation database a license enables—is the only practical solution to ensuring continuity of operations for these entities going forward. In addition to any potential reduction of reserve channel allocations, the repacking of television stations will reduce the amount of TV White Space available for any wireless microphone operator, licensed or unlicensed. Therefore, given the Commission's proposals in the *Incentive Auction NPRM*, the public interest requires that the license eligibility rules for wireless microphones be updated and expanded in order to recognize the equivalent importance of all professional uses of the equipment and to avoid the interference that would wreak havoc on professional productions in every sector.

B. An expansion of license eligibility will not hinder unlicensed devices

Unlicensed devices currently have access to hundreds of megahertz of spectrum at 2.4 GHz, 5 GHz, and other bands. Wireless microphones in most professional productions, due to

their high performance standards, technical requirements, and historical worldwide allocation, operate in a much more limited band of spectrum. At this time, the majority of wireless microphones are developed and deployed in the UHF band and thus will suffer the greatest harm from the reduction in available spectrum in this band.[41] The fact is wireless microphones do not have access to sufficient UHF spectrum *today* to meet the needs of many professionally produced large events, and the Commission's proposal in the *Incentive Auction NPRM* to auction further TV Band spectrum and allocate the guard bands for the exclusive use of unlicensed devices, if adopted, will further exacerbate the spectrum availability disparity between consumer products and professional audio equipment.

TV White Space rules are predicated on the understanding that wireless microphones share spectrum efficiently; during a performance, broadcast, public forum, or similar event, a wireless microphone utilizes the necessary spectrum to deliver clear audio to the audience and, once the performance or event is over and the microphone is turned off, that spectrum is then free and available for other uses. As such, wireless microphones are very efficient users of spectrum and only require that spectrum for a defined period of time in a defined location. As the Commission noted, "[t]he nature of wireless microphones and their use is such that they operate for relatively short intervals at different times, and the specific frequencies they use for operation often change, even when used in one location."[42]

Licensed and unlicensed professional users of wireless microphones have equivalent operating parameters and requirements for quality of service and therefore should have equivalent consideration for the rights associated with licenses, including near-real time database

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[41] "Retuning" wireless microphones to operate in a different frequency band generally cannot be accomplished through a mere adjustment by a dealer or manufacturer's service agent and cannot be accomplished by an operator in the field. In most cases, the change to a new frequency band will require such a substantial modification by the manufacturer that a wholesale replacement is the only practical option.

[42] *Incentive Auction NPRM* at ¶ 223.

registration of the time and place of productions to ensure interference protection. Even with an expansion of license-eligible professional audio users, significant spectrum will still remain for the operation of unlicensed devices. Without expansion, the balance of available UHF spectrum risks being tipped disproportionately in favor of content consumers over content producers.

VII. Proposed Implementation of Expanded Licensing for Wireless Microphones

A. Professional users of wireless microphones should be eligible for licenses

Shure specifically proposes that the Part 74 eligibility rules authorize FCC licensing to include professional use of wireless microphones. Professional use must be defined to include the full range of users that require the high quality and reliability to serve their needs and the demands of their audiences. While the FCC has not previously defined "professional" in a licensing context, in the White Spaces proceeding it did define "professional installer" as "an entity consisting of an individual or team of individuals with experience in installing radio communications equipment and that provides service on a fee basis – such an individual or team can generally be expected to be capable of ascertaining the geographic coordinates of a site and entering them into the device for communication to a database."[43] In the context of wireless microphone usage, professional use would be similar to the concept of a "professional installer," since it typically takes place in controlled settings where skilled personnel are responsible for the microphone operations. In Shure's experience, all professionals that would qualify for licensing would likely have engaged an experienced facilities, technology, or frequency coordinator who is responsible for wireless microphone operation at these locations or events and who would be responsible for frequency selection and registration in the database.

In addition, each case of professional use would include only those instances where wireless microphones are an integral part of the production and the inability to use wireless

[43] *White Spaces Second Order* at ¶ 150.

microphones free from interference will substantially undermine the event. As part of the application process, applicants would be asked to certify that the license will be used for professional wireless microphone operations.

While licensing could be limited to professional uses, as an initial matter, the FCC should not try to limit licensing based on a value judgment about the *content* being transmitted by the wireless microphone in use. Just as the Commission has not and should not attempt to determine the likely nature of transmissions supported by White Space devices, smartphones, or other LTE devices and limit or favor the operational rights for certain data and video transmissions over other transmissions, it should not attempt to make similar determinations about the use of wireless microphones. This type of inquiry is fundamentally inconsistent with the basic mandate of the Communications Act and would mire the Commission in a hopeless and inappropriate assessment of the relative values of content such as whether religious content should take precedence over political content or whether educational content should take precedence over entertainment.

The Commission should also generally steer clear of building into the rules arbitrary assumptions about the use of wireless microphones and the need for interference protection. For instance, while it is true that some of the largest, most complex productions such as large civic, music, and theater events require licensing and interference protection in the database, the same can be said for many smaller productions. In light of the proposal to eliminate the microphone reserve channels and dramatically reduce access to UHF spectrum, it is also inappropriate to use the number of microphones used as a criterion for licensing and database protection. In the absence of clean spectrum, the wireless microphone for the single presenter—*e.g.*, Apple CEO Tim Cook speaking at a new Apple product launch—must be protected from interference.

Adopting licensing eligibility for professional use, along with other reasonable limitations proposed below, is consistent with the Commission's sparse requirements for other wireless licenses. With few exceptions, eligibility for wireless licenses have no detailed nontechnical requirements and are generally limited only by the federal statutory limitations on foreign ownership[44] or, in some cases, to educational, governmental or similar entities.[45] While Shure supports rational and logical eligibility requirements for wireless microphone licenses, it urges the Commission to move forward with expanded eligibility for all professional users.

B. Other reasonable licensing requirements should be adopted

1. Mobility: Given the fundamental nature and purpose of wireless microphones, it is reasonable for the FCC to require license applicants to certify that the proposed uses of the performers, crew, or other users require mobility of operation.

2. Venues: Shure proposes that license eligibility be expanded to include venues that host events where the professional use of wireless microphones is an integral part of the performance, presentation, or exhibition.

Such professional venues include:

- indoor and outdoor seated facilities, including auditoriums, amphitheaters, arenas, stadiums, and theaters; and
- indoor and outdoor venues without fixed seating, including convention centers, conference facilities, amusement parks, fairgrounds, entertainment, athletic, religious, educational, government and cultural facilities.

Shure urges the Commission to avoid using raw seat count, room capacity, building dimensions and the like as criteria for venue license eligibility. Small venues can hold high priority events. For example, major international artists such as The Rolling Stones can often be

[44] *See* 47 C.F.R. § 22.7 ("Any entity, other than those precluded by section 310 of the Communications Act of 1934, as amended, 47 U.S.C. 310, is eligible to hold a license under this part."). *See also* 47 C.F.R. §§ 24.12, 27.12.

[45] *See. e.g*., 47.C.F.R. § 90.20(a) (restricting public safety licenses to local and state government entities or organizations working in fire protection, forestry conservation, medical services and rescue squads).

seen adding unplanned, "exclusive" performances for fans in intimate settings while on or prior to large arena tours. Additionally, it is customary for large touring productions to hold extensive technical rehearsals in facilities dedicated to this activity (*e.g.*, SoundCheck in Nashville, TN) and in which no audience seating is present, but the expectation for flawless equipment performance is pivotal. In these and other instances, establishing an artificial threshold for venue license eligibility based on audience capacity would be insufficient criteria.

3. Licensed Party: The Commission should adopt flexible rules regarding which entity may hold a license. The rules should allow for licensing by the venue owner, operator, event producer, responsible technical engineer, the event sponsor, performer, or audio rental house. The license applicant should be required to certify that the licensed wireless microphone would be used for permissible (professional/mobile) purposes at permissible locations. In most cases, the firm or individuals responsible for ensuring a flawless performance will want to hold the necessary license in order to ensure proper registration in the database.

Finally, the application process for wireless microphone and related equipment licenses should be simplified. Currently, Part 74 LPAS license application forms are overly complex, leading to excessive costs and delays for interested parties. Shure believes that requirements for obtaining a license to operate wireless microphones could be greatly streamlined without negative effects to the Commission or other users of the spectrum.

VIII. Co-Channel Operation with TV Stations Should be Further Evaluated

Shure supports the Commission's "co-channel operation" proposal, but the Commission should be acutely aware that although such change may free up some additional spectrum in some locations and under certain situations, it will not compensate for the projected loss of UHF spectrum availability to wireless microphones. As spectrum becomes increasingly scarce, the Commission should be open to innovative ways to make more intensive use of it, including

reviewing co-channel limitations. Currently, the FCC rules specify a minimum spacing of 113 km between wireless microphones and TV transmitters without regard to other relevant technical parameters.[46] In order to make the most efficient use of the spectrum, the Commission should consider defining the separation requirement on a more technically complete basis that includes the predicted contour of the TV station and the radiated power of the wireless microphone. This step would expand the geographic area in which wireless microphones could operate by taking into account the actual location of the station's transmission, including the direction of its contour and the impact of local geography (such as hills or mountains) on the actual TV signal. By including such relevant data points in the database, wireless microphone users could better utilize available spectrum without interfering with television signals.

In addition, there are special circumstances under which wireless microphones could operate on locally used co-channel TV frequencies within the TV station's contour without causing interference, such as inside buildings or other structures where over-the-air TV signals are not receivable or where no over-the-air receivers are in operation. The availability of White Space databases presents the possibility of allowing co-channel operation of licensed wireless microphones through database registration. In the event that any interference were to occur, the source could be identified through the database and turned off.

IX. The Licensing and Database Requirements and Procedures Must Be Revised to Improve Wireless Microphone Protection and Enhance Efficient Use of Spectrum

The Commission's existing rules for registration of unlicensed wireless microphones are complex, unwieldy, and impractical for many users. Currently, operators of unlicensed wireless microphones for large events or productions must seek authority from the Commission at least

[46] 47 C.F.R. §74.802(b)(3).

30 days in advance of the event.[47] In reality, such requirements are unworkable due to many unforeseeable changes in the frequency coordination process for complex events or the simple realities of program scheduling. Frequency planning is a dynamic task that often requires flexibility leading up to the event or even at the event. As the Broadway League previously informed the Commission, "registering frequencies at specific locations thirty days in advance will be a problem in areas with heavy use where coordination among users is routine and where changes are often necessary right up to the time of performance."[48]

After an expansion of license eligibility to qualified professional users has been established, and in order to alleviate the unnecessary burden on registrants and fully exercise the capabilities of the geolocation databases, Shure proposes modifications to the registration process for the remaining unlicensed wireless microphone users. First, Shure recommends that the thirty day approval period be eliminated for qualified unlicensed users. The approval period could be applied to an initial request application, and once approved, subject to an annual or bi-annual renewal. These changes would significantly streamline the process, making it more user friendly and less burdensome while retaining the necessary ability to monitor and track user registrations.

Finally, in order to address the realities of contemporary event production and to ensure the most efficient use of spectrum for *all* parties—licensed and unlicensed, professional and consumer—the databases should be required to synchronize updates as close as possible to real time. The current 48-hour window permitted in the rules effectively limits the utility and reliability of the database system for professional audio users, who require a much more responsive system to meet the need for high reliability while managing a dynamic frequency

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[47] 47 C.F.R. § 15.713(h)(9).

[48] *See* Ex Parte Presentation of the Broadway League, WT Docket Nos. 08-166, 08-167, ET Docket Nos. 04-186, 10-24, at 1 (filed Jan. 27, 2011).

coordination process. The currently authorized database administrators have already agreed in principle to synchronize and update their registration data every 15 minutes.[49] There is no technical or policy justification for not tightening the current 48-hour window in the rules. Real-world RF environments change quickly (*e.g.*, the environment at FedEx Field looks completely different one hour before the game and at kickoff), and the database rules should be practical by allowing users to respond to and address these realities in order to provide meaningful protections. Furthermore, event schedules often must be changed due to weather, illness, emergencies, or added performances. Professional audio users will benefit from the higher certainty of protection afforded by real time updates, but unlicensed consumer devices will reap an equivalent benefit as spectrum is freed for their use much closer to the actual time of the database reservation.

X. Clear Spectrum is Required to Take Advantage of Advanced, Spectrally Efficient Digital Technologies

The Commission seeks comment on a potential long-term solution to "help ensure that wireless microphones operate more efficiently and effectively."[50] In particular, the Commission posits that a shift from analog to digital technologies would "improve spectrum efficiency and resistance to interference."[51] Manufacturers have made significant advances in the spectral efficiency of wireless microphones over the past several years, substantially increasing the number of microphones that can operate within a single television channel. Digital microphones are increasing in quality and availability, although analog units still represent the majority of

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[49] *See* White Space DBA Group Database to Database Synchronization and Interoperability Subgroup, Presentation to FCC, at 3 (May 25, 2011), *available at* http://transition.fcc.gov/bureaus/oet/whitespace/TVWS_Workshop3/White_Space_DBA_DB_Interoperabilty_Slides_110525.pdf

[50] *Wireless Microphone Notice* at 5.

[51] *Id.* at 6.

systems in operation today. However, regardless of whether the technology in use is analog or digital, efficiency gains cannot make up for radical reductions in UHF spectrum.

A. Digital wireless microphones are an emerging technology, but analog systems still represent the majority of systems in operation

The Commission seeks detailed input on the use of "more efficient advanced digital technologies."[52] The use of digital technology for wireless audio is increasing, but analog systems still represent the majority of systems in use. While digital technology has improved, there are important tradeoffs vis-á-vis analog transmission. The interplay of various design elements (audio coding, error coding, compression, modulation, intermodulation distortion ("IMD") and receiver selectivity) makes it difficult to simultaneously achieve high spectrum efficiency and robustness against interference, while providing the low latency necessary for live performances.[53] Given these challenges, some of the currently available digital wireless microphones are less spectrally efficient than the leading analog models for the same audio quality and working range. In addition, efficiency improvements that can be achieved through the use of digital technology cannot be achieved in the absence of clean, interference-free UHF spectrum.

In FMDA signaling (as used in the UHF band), digital wireless microphone spectrum efficiency is dominated by five design variables: (1) audio compression (bits out/bits in), (2) forward error correction, (3) modulation efficiency (bits/Hz), (4) IMD, and (5) receiver selectivity. While increased audio compression can increase spectrum efficiency, this must be done in a way that minimizes latency. Similarly, the error correction applied to a digital wireless

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52 *Id.*

53 Digital technology has the unique ability to leverage the interplay of various design elements (audio coding, error coding, modulation, IMD and receiver selectivity) in order to offer improved spectrum efficiency when quality of service requirements and the RF environment permit. The need for robustness against interference consumes valuable data capacity to implement error coding and therefore hampers the ability to maximize spectral efficiency. To operate as efficiently as possible, digital wireless systems must have access to clean, interference-free spectrum.

transmission affects the spectrum efficiency because it adds information that is used to mitigate and correct errors. This information increases the transmission bandwidth or the throughput delay, depending on what tradeoffs are made. High-efficiency modulation designs offer increased spectrum efficiency; however, they also require clean, stable spectrum and a higher carrier-to-noise ratio to operate properly.

IMD exists when two or more transmitters of any kind (analog or digital) are in close proximity to each other and creates additional unwanted carriers above and below the frequencies of the two desired carriers. Reducing the amount of IMD increases the spectrum efficiency, but it normally results in a more complex and expensive RF design, with higher power consumption and less battery life. IMD can be produced anywhere in the system, including the transmitters, receivers, and antenna amplifiers, but typically is dominated by transmitter-to-transmitter IMD in wireless microphone systems. The number of unwanted IMD products in a wireless microphone system increases exponentially with the number of microphone transmitters, so IMD products can have a large effect on the spectrum efficiency of wireless microphones. IMD products reduce the spectral efficiency of the wireless microphone systems since the frequencies occupied by unwanted carriers cannot be used and as a result, transmitter frequencies need to be spaced farther apart.

Receiver selectivity also affects the wireless microphone frequency spacing and therefore the spectrum efficiency. Increasing receiver selectivity may, in some cases, allow transmitters to be spaced closer together in frequency without IMD or overload at the receiver, but it requires a combination of sophisticated analog and digital filters to implement a matched filter design, which increases the design cost and complexity. Transmitter adjacent channel power is equally as important a consideration, since it lands on-channel and cannot be filtered out by the receiver.

The following table summarizes the design variables affecting spectrum efficiency and the tradeoffs to the wireless microphone performance:

Design Variable	**To Increase Spectrum Efficiency**	**At the Expense of**
Source Code Compression	Increase	Higher system latency
Error coding/Data redundancy	Decrease	SNR performance and interference immunity
Modulation Efficiency	Increase	Lower operating range, less interference immunity, higher design cost and complexity
Inter-Modulation Distortion	Decrease	Less battery life, higher design cost
Receiver Selectivity	Increase	Higher design cost and complexity

B. Digital technologies require clean spectrum to provide substantial efficiency gains

The Commission asked a series of detailed questions regarding the development of digital technologies and, in particular, the current efficiencies available. While some digital wireless products are now available in the high-end professional audio market, digital wireless technology is not a panacea for insufficient spectrum allocations. A small number of professional digital wireless microphones are currently available in the market for operation in the UHF spectrum (*e.g.*, Shure ULX-D, Sennheiser 9000, Sony DWX, AKG DMS700, Beyerdynamic TG 1000, Mipro ACT). All have similar specifications and design topologies (< 5msec latency, 200kHz occupied bandwidth, >100dB audio dynamic range, digital phase/frequency modulation, 50-100 meter operating range). The spectrum efficiency of these systems range from 10 to 17 wireless microphones per television channel under normal operating conditions.

With digital wireless technology, as previously mentioned, there is a tradeoff between spectrum efficiency and interference protection. For example, 802.11g uses a multi-level modulation system that is changed in real-time based on the channel quality; a higher modulation

efficiency (high spectrum efficiency) is chosen when the channel quality is good (no interference and/or low number of other users of that channel), and a lower modulation efficiency (low spectrum efficiency) is chosen when the channel quality is poor (such as when high levels of interference are present).

Shure manufactures a wireless microphone system that can support the operation of up to 47 microphones in one UHF TV channel in High Density mode.[54] This mode utilizes higher order modulation and requires the transmitters to be operated at a lower power level to eliminate IMD concerns, which reduces the operating range to 30 meters. This level of efficiency cannot be achieved unless the channel is free of interference from outside sources. At full power in standard mode, this system allows a total of 17 wireless microphones to be operated in one TV channel, which is comparable to the best analog systems available.

A significant improvement in spectrum efficiency cannot be achieved merely by "facilitating" a rapid conversion from analog to digital transmission. In order to achieve the highest spectrum efficiency possible, both analog and digital wireless devices must have clean, stable UHF spectrum in which to operate. Spectrum efficiency is affected by both in-band and out-of-band sources of interference and noise. In particular, other types of wireless systems operating in adjacent channels or bands can dramatically reduce spectrum efficiency if they produce high levels of spurious emissions within the wireless microphone operating channel.

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[54] Recognizing the spectrum crunch that already exists for wireless microphone users due to the loss of the repurposed 700 MHz band, Shure has taken the lead in providing a significant improvement in spectral efficiency by developing a high density mode within the ULX-D product line. Leveraging the flexibility of a digital platform, this mode of operation offers the user over twice the number of channels per MHz than the standard mode. This comes at the expense of reduced range but is useful for conference settings, classrooms, and small theaters, where the required coverage area is less than 30 meters, and the interference level is relatively low. In its standard mode, the Shure ULX-D system offers spectral efficiency that is comparable to today's high end analog systems and provides the range and interference robustness required for the most demanding professional applications. Shure views this as a significant first step to improving the overall spectral efficiency of our wireless products and is committed to pursuing continued improvements while maintaining the critical audio quality requirements that our customers demand. However, these efficiency gains cannot make up for radical reductions in UHF spectrum.

XI. Filters Provide Some Protection Against Inter-Modulation Distortion Interference But Cannot Solve All Interference Problems

While filters may sometimes be used to mitigate the effects of interference and to maintain or improve efficiency, they cannot resolve all technical problems. Filters represent a significant cost element, often have limited bandwidth over which they can function, and can be too large for use in small handheld and body worn transmitters required for live sound applications. In FDMA systems where the transmitters are in continuous operation, IMD is generally not mitigated through the use of filters as the filter would need to have an extremely small bandwidth, be tunable over a wide frequency range, be in a small form-factor, and be low in cost. Also, applying filters at the input of wireless receivers can only reduce IMD interference but not eliminate it. Therefore, to increase spectrum efficiency, IMD interference needs to be addressed at the transmitter.

IMD is typically mitigated through the use of two complementary techniques; 1) ferrite isolators, and 2) low-distortion RF power amplifier designs. Ferrite isolators are passive devices that are placed at the output of wireless microphone transmitters; they allow the intentional transmitter signal to flow out to the antenna, but direct any unwanted incoming energy (from another transmitter) to a terminated load and away from the power amplifier, thereby reducing the amount of IMD produced between transmitters. Isolators are used in some existing wireless microphone transmitters today; however, they are not tunable devices, have limited frequency bandwidth, are expensive components, and are physically large (size is inversely related to operating frequency). Isolators also have a certain amount of forward insertion loss so the output power of the final amplifier must be increased to compensate for the loss due to the isolator.

Low-distortion RF power amplifiers are used in some wireless microphone transmitters to minimize IMD products. These amplifiers are designed to operate in a linear mode and reject

unwanted incoming signals seen at the power amplifier output. Low-distortion RF power amplifiers are accomplished with a variety of design techniques and typically require expensive devices and substrates, high DC power consumption and excellent shielding. Increasing the DC power consumption negatively impacts battery life, an important user requirement. Achieving these designs over a wide frequency range is a further complicating design challenge.

XII. Improvements in Spectral Efficiency Require Tradeoffs in Audio Quality and Latency

The audio fidelity of a wireless microphone system is measured via a collection of techniques and characterizations; typical static measurements include frequency response, signal-to-noise ratio, total-harmonic distortion, transient response, linearity and latency. Other dynamic audio quality measurements include audio artifacts from harsh/complex source material and squelch, diversity and muting behavior in the presence of interference, multi-path fading and at the end of range.[55]

Available digital wireless microphones generally operate with lower RF output power than comparable analog models due to the challenges of meeting spectrum masks and spectrum re-growth from non-linear RF power amplifier designs. Lower RF output power results in lower operating distances and reduced immunity from unwanted sources such as video walls. Users generally consider problems in these areas with wireless microphones to be "audio quality" issues as they are often unaware of the causes of radio frequency interference.

[55] Quality of service ("QoS") requirements are well known in the data communications industry. They determine the data integrity and latency requirements for delivering high quality media content. Wireless microphones have a range of QoS requirements that are dependent on the particular application. The primary metrics are perceived audio quality, tolerance for dropouts or audio artifacts, and latency. Certainly in a qualitative sense, QoS requirements for wireless microphone applications range from high to very high, which makes the system design challenging. Professional audio performance applications have very stringent QoS requirements. Once they are properly defined, data communication principles can be applied to define a system to meet these requirements. The Shure ULX-D is an example of such a system.

Unlike other types of wireless communications such as data and email, wireless audio usually demands a low level of latency, particularly for live performance applications. All digital wireless microphones exhibit a certain amount of throughput delay, whereas analog microphones generally have almost none. The latency of most professional digital wireless microphones is typically < 5msec from transmitter input to receiver output while most professional analog wireless microphones have latency of < 0.5msec. The majority of professional digital wireless microphones use time-domain source coding that operates on a very low number of audio samples at a time for low latency at a modest reduction in the output bit rate. This process is different than frequency-domain source coding (or "block-coding") where large blocks of audio samples are processed at once for a larger reduction in the output bit rate. "Block-coding" is typically used in portable audio players and carries a very high latency penalty for the very low bit-rate; block-coding latency is unacceptable in real-time professional audio applications.

The sensitivity to latency in sound production applications varies dramatically with the user, venue size, source material (instrument or voice), sound reinforcement and local feedback to the user. It is also important to note that the latency due to the wireless microphone is only part of the total latency of the whole reinforced sound system and natural venue delay, which often combine together at the user's ears.

XIII. Allocation of Clean UHF Spectrum and Expanded Licensing Will Promote Further Development of Digital Wireless Microphones

The Commission asks for input on what steps it can take to require or encourage further development of digital wireless microphones.[56] First, and foremost, the Commission must be aware that investment and expansion of digital technologies depends on the availability of

[56] *Wireless Microphone Notice* at 6.

dedicated, clean, stable UHF spectrum. The FCC has already established clean UHF spectrum for the use of wireless microphones in the White Spaces proceeding through the adoption of two reserve channels. If the FCC maintains the two reserve channels, manufacturers and users will have the necessary assurance to invest in research and development and make capital expenditures in new equipment that they know can operate in clean spectrum for many years to come. Without the assurance of the availability of clean UHF spectrum, there is little incentive for investment in new digital equipment. In addition, expanded license eligibility will help promote future investment. Expanding the wireless microphone license eligibility and access to the wireless microphone database will promote investment in digital technologies to increase spectrum efficiency.

Further, maintaining the reserved channels in the UHF band will also promote future investment in digital wireless technologies by establishing spectrum use rules consistent with wireless microphone UHF band use in other countries around the world. Maintaining the reserve wireless microphone channels in UHF will maximize R&D investment, reduce product cost, ease regulatory compliance burdens, and protect users that purchased new wireless microphone products during the 700MHz transition.

XIV. A Reduction in Bandwidth Below 200 kHz Will Align with International Standards and Promote Spectrum Efficiency

Among other possible steps, the Commission asks whether it could promote efficiency by imposing a requirement to reduce occupied bandwidth below 200 kHz over a period of time.[57] Shure agrees that the Commission should reduce the permissible occupied bandwidth below 200 kHz for both analog and digital wireless microphones. This step will immediately increase spectrum efficiency in the marketplace. These tighter limits would help promote better use of

[57] *Id.* at 5-6.

scarce spectrum resources and improve compatibility between different wireless microphone systems. In particular, it is reasonable to harmonize the occupied bandwidth of wireless microphones in the United States to that found in EN 300 422 used in the European Union. The timeframe for new products to be type-approved by the FCC to the new bandwidth mask should be no later than January 1, 2015. The Commission should also establish a transition period of 10 years for currently approved products.

XV. The Commission Should Not Adopt Spectral Efficiency Standards But Allow the Marketplace to Continue to Develop and Innovate

The Commission asks whether to adopt specific efficiency standards.[58] Shure opposes the creation of spectrum efficiency standards for wireless microphones. Any such requirements would be premature and would only serve to hamper investment and innovation. The Commission is not in a position to dictate standards without significant risk of inhibiting further innovation. Natural market forces have already accelerated efficiency development. Agency regulation is not only unnecessary, it risks wrongly directing development and investment to static, inflexible and possibly inappropriate standards.

As the Commission is already aware, the efficiency of wireless microphones has increased dramatically over the last ten years in response to the developments in technology and in response to demands from productions that required a larger number of frequencies operating in less UHF spectrum due to the 700 MHz transition. Likewise, the incentive auctions will naturally incentivize manufacturers to increase spectrum efficiency as a result of the reduction in available UHF spectrum. Further, maintaining two reserve channels in UHF for wireless microphone operation will stimulate investment in wireless microphone technology and promote spectrum efficiency at the same time. Instead of imposing unnecessary and restrictive

[58] *Id.* at 6.

requirements that would harm smaller companies and manufacturers, the Commission should allow further developments to continue as a result of the marketplace and technological developments.

XVI. The Commission Should Not Adopt a Mandatory Transition to Digital Wireless Microphones

As described in detail in these comments, the wireless microphone industry is in the process of transitioning to the use of digital technology, but for users, this transition is just beginning. The majority of professional wireless microphone equipment in use today is analog. Furthermore, analog wireless microphones are still preferred for certain applications. The professional wireless microphone market will naturally produce more digital wireless products as technology advances. Shure believes both analog and digital wireless microphones should be allowed to operate in the UHF spectrum equally. Furthermore, users have made a huge investment in analog equipment during the 700 MHz transition that is capable of providing satisfactory service for many years. Therefore, it would be detrimental for the FCC to impose a mandatory transition to digital wireless microphones.

XVII. Harmonization of the Part 74 Rules and Revisions to the Out of Band Emission Limits For New Systems Operating in Adjacent Bands Would Encourage Development

Due to its longer wavelength, higher ambient radio noise levels, and less favorable propagation characteristics, the VHF band is not widely used by professional wireless microphones at the present time. To encourage greater use of this band, the Commission should harmonize the Part 74 technical rules to permit wireless microphones to operate with the same power levels (up to 250 mW) they can use in the UHF band. Small antennas for use with body packs and handheld transmitters are inherently less efficient in the VHF band, and higher power

is required for some applications to overcome high background noise levels and to replicate the range and reliability of comparable UHF band equipment.

The Commission should also study and establish appropriate limits on out-of-band emissions from new kinds of systems operating in adjacent cleared bands after the repacking of UHF spectrum. Emissions from LTE equipment tend to be very high outside their occupied bands due to the dynamic behavior of these systems as resource blocks and power levels are changed. Therefore, additional limitations may be necessary in order to protect services operating in adjacent channels.

XVIII. Shure Urges the Commission to Adopt Several Administrative Changes to Ease Regulatory Burdens

The present wireless microphone license application procedure was designed to cover a wide range of situations and is overly complex and burdensome. The Commission should adopt a simplified licensing process that is more efficient and which would encourage use of the licensing and registration systems. A simpler procedure that is more appropriate for these very low power devices is needed.

In addition, the technical rules in Part 74 and Part 15 should incorporate the necessary cross-references in order to simplify the certification processes. In 2008, the Commission decided to temporarily allow unlicensed wireless microphones and audio devices to operate in the TV bands in accordance with the technical rules contained in Part 74, Subpart H,[59] subject to a reduced power limit of 50 mW. This arrangement has worked well and, as far as Shure is aware, has not resulted in any complaints of interference. Shure therefore requests that the Commission incorporate this provision in its technical rules, preferably in Part 15 with a reference to the other technical requirements in Part 74, Subpart H.

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[59] *See White Spaces Order.*

Respectfully submitted,

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